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SHARMAINE WU (Ms)
Assistant Registrar
*for* REGISTRAR OF PATENTS

# DUAL-SPEED DRIVE MECHANISM

## BACKGROUND

1. Field of the Invention

The present invention relates generally to printers, and more particularly to printers that move the print media in and out quickly but slow down the movement through during actual printing of the images.

2. Background of the Invention

Conventional laser and inkjet printers, faxes, and copiers feed the printing paper through at one speed. The speed chosen usually represents a compromise between high throughput and the need for precision while actually laying down the image on paper. In many prior art printers, a motor is coupled to a drive roller through a system of gears.

A zero-backlash way to get a speed reduction in a compact coaxial arrangement is through the use of a "harmonic drive" unit. Industrial precision speed reducers of this type are marketed for use in robots, semiconductor manufacturing equipment, steppers, factory automation (FA) equipment, mechatronic gears for finely-tuned motions, and other industrial applications. A harmonic drive is described in United States Patent 4,909,098, issued March 20, 1990, to Yuichi Kiryu.

## SUMMARY OF THE INVENTION

Briefly, a drive mechanism embodiment of the present invention for feeding a media sheet in a printer includes a drive motor, a drive roller for feeding media sheets toward and through a printing area, and a transmission system for connecting the drive roller to the motor to provide two-speed power to the drive roller. Furthermore, a speed selector is disposed in the transmission system for selectively turning the drive roller at a fast speed to

move said media sheets quickly to and out of said printing area, and for selectively turning the drive roller at a slow speed to move said media sheets with precision for image printing while in said printing area.

According to a second embodiment of the present invention, a method for feeding a media sheet in a printer is provided. A media sheet is quickly fed up to a print zone in the printer. Once in position for printing, a reduced speed is used to feed the paper through the print zone to provide precise paper control.

These and other objects and advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiments which are illustrated in the various drawing figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional diagram of a printer drive mechanism embodiment of the present invention;

Fig. 2 is a cross sectional diagram illustrating in details another printer drive mechanism embodiment of the present invention; and

Fig. 3 illustrates step-by-step the process advancing a media sheet by the drive mechanism of Fig. 2.

## DETAILED DESCRIPTION

Fig. 1 illustrates a drive mechanism embodiment of the present invention for feeding paper and other print media sheets through a printer, and is referred to herein by the general reference number 100. Such printer is

representative of the many kinds of devices that use drive mechanisms that can benefit from the present invention. For example, some fax and copier machines are included in alternative embodiments of the present invention.

The drive mechanism 100 is mounted to a printer chassis and includes a motor 101 providing power and a driver 103 feeding media sheets towards and through a printing area for image printing. A drive transmission 105 connects the drive roller 103 to the motor 101 for turning the drive roller 103 at a variety of speeds. A selector 107 is disposed in the transmission 105 for selectively turning the drive roller 103 at a fast speed to move the media sheets quickly to and out of the printing area, and for selectively turning the drive roller 103 at a slow speed to move the media sheets with precision for image printing while in the printing area.

Fig. 2 illustrates in details another drive mechanism embodiment of the present invention, referred to herein by the general reference number 200. The drive mechanism 200 includes a DC motor 201 providing power, a drive roller 203, and a drive roller shaft 205. The media sheets are fed towards and through a print zone for printing. A motor shaft 207 is coupled to and rotates together with the motor 201 for transmitting power to other parts of the drive mechanism 200. In addition, an encoder disc 209 mounted to the motor shaft 207 works with an optical sensor 211 mounted on the chassis to detect rotational positions of the motor 201, which correspond to the rotational positions of the drive roller 203. The detected rotational positions of the motor will be fed back to a control mechanism (not shown) for monitoring rotation of the motor 201.

Power provided by the motor 201 is transmitted through one of a pair of transmission mechanisms 213, 215 to the drive roller 203. A low-reduction gear train 213 and a harmonic drive 215 are provided in the drive mechanism 200 as the transmission mechanisms.

The harmonic drive 215 assures high positional/rotational accuracy and provides a high-reduction ratio of, for example, 1/30-1/320. Therefore, when power is transmitted from the motor 201 through the harmonic drive 215 to the drive roller 203, the drive roller 203 rotates at a relatively low speed and provides a highly precise paper advance. The harmonic drive 215 includes a wave generator 217, a flexspline 219 and a circular spline 221; the three components are generally mounted coaxially. The wave generator 217 is rotatable about the motor shaft 207 and is engagable with a clutch gear 223 for receiving power therefrom; the circular spline 221 has a plurality of external engaging teeth (not shown) and is rigidly fixed to the drive roller shaft 205 for providing the output drive force to the drive roller 203. More detailed information about the harmonic drive is available at http://www.globaltec.thai.com/sub2/sub2c.htm, or http://www.harmonic-drive.com/indexproducts.html.

The harmonic drive mainly includes a wave generator, a flexspline and a circular spline. The wave generator typically has bearings, such as ball bearings, built into the outer circumference of an elliptical cam. An inner raceway of bearings is fixed to the cam, and an outer raceway is elastically deformed by pressure applied by the bearings. The wave generator is attached to an input shaft. The flexpline includes a thin cup-shaped metal rim with external teeth and is fixed to prevent absolute rotational motion. The circular spline is a rigid steel ring with internal teeth. The circular spline has more teeth than the flexspline and is fixed to a casing which, in turn, is fixed to an output shaft. In operation, the flexspline is deflected by the wave generator into an elliptical shape causing the flexspline teeth to engage with those of the circular spline at the major axis of the wave generator ellipse, with the teeth completely disengaged across the minor axis of the ellipse. When the wave generator is rotated clockwise with the flexspline fixed from rotating, the flexspline is subjected to elastic deformation and its tooth

engagement position moves by turns relative to the circular spline. For example, if the circular spline has two more teeth than the flexspline, when the wave generator rotates 180 degrees clockwise, the flexspline tends to want to move counterclockwise by one tooth relative to the circular spline. However, since the flexspline is fixed from rotating, the circular spline is forced to rotate in a clockwise direction. Furthermore, when the wave generator rotates one revolution clockwise (360 degrees), the flexspline tends to want to move counterclockwise by two teeth relative to the circular spline because, in this example, the flexspline has two fewer teeth than the circular spline. Again, since the flexspline is fixed from rotating, the circular spline is forced to rotate in a clockwise direction, and in general terms, this movement is treated as output power. The low-reduction gear train 213 provides a relatively low-reduction ratio of, for example, 1:4 to 1:10. Therefore, when power is transmitted from the motor 201 through the low-reduction gear train 213 to the drive roller 103, the drive roller 203 rotates at a relatively high speed. The low-reduction gear train 213 includes a high speed advance gear 225 rotatable about the motor shaft 207 and is engagable with the clutch gear 223 for receiving power from the motor 201. Power is then transmitted through a second gear 227, a gear shaft 229 and a third gear 231 engaged with the external teeth of the circular spline 221 of the harmonic drive 213. In this way, power is transmitted to the drive roller 203 further through the circular spline 221 and the drive roller shaft 205.

Therefore, the exemplary drive mechanism 200 can operate in one of the two drive modes: 1) a first mode, in which the motor 201 drives the drive roller 103 through the low-reduction gear train 213, and the drive roller 203 feeds the media sheet at a relatively high speed, and 2) a second mode, in which the motor drives the drive roller 203 through the harmonic drive 215, and the drive roller 203 feeds the media sheet at a relatively low speed with a highly precise paper advance.

Preferably, the exemplary drive mechanism 200 operates in the first mode before the media sheet has reached the print zone and after image printing, while in the second mode during printing operations when the media is being advanced through the print zone having high resolution images imprinted thereon. As shown in Fig.3, in step 301, the media sheet is firstly advanced at a high speed towards the print zone before it has reached the printing area. Then in step 303, when the media sheet is in the printing area for image printing, the media sheet is fed at a reduced speed through the print zone. After the image printing is finished, in step 303, the media sheet is again fed at the high speed towards the output area of the printer. In this way, the exemplary drive mechanism 200 achieves a highly precise paper advance during the printing of images while simultaneously enabling a relatively high throughput.

Selection of the drive mode is achieved through the clutch gear 223. The clutch gear 223 is located between the low-reduction gear train 213 and the harmonic drive 215 in the drive mechanism 200, and selectively engages one of the transmission mechanisms with the motor shaft 207 such that power can be transmitted to the drive roller 203 through such a transmission mechanism. The clutch gear 223 is mounted to and rotates together with the motor shaft 207 for thereby receiving power. Furthermore, the clutch gear 223 is movable axially along an axis 233 of the motor shaft 207 between a first and a second positions (not shown), where the clutch gear 223 engages one of the transmission mechanisms respectively. By controlling the selective engagement of the clutch gear 223 with the transmission mechanisms, the exemplary drive mechanism 200 operates in one of the drive modes accordingly.

Depending on the position of the clutch gear 223, there are two separate paths of motion transmitted from the motor 201 to the drive roller 203.

Firstly, for the combination of a high speed and low precision linefeed advance, the clutch gear 223 moves towards the motor 201 to engage the high speed advance gear 225. This directly transmits the motion or drive force from the motor 201 to the high speed advance gear 225. It should be noted that both the encoder disk 209 and the clutch gear 223 are keyed to the motor shaft 207 to ensure direct motion of the motor 201 to the high speed advance gear 225. The motion will then transfer from the high speed advance gear 225 to the second gear 227, the gear shaft 229 and the third gear 231. Thus, the motion will be directed directly through the low-reduction gear train 211 from the motor 201 to the circular spline 221. Finally, as the circular spline 221 is rigidly connected to the drive roller shaft 205, the motion from the motor 201 to the drive roller 203 is complete.

As for the combination of a low speed and high precision linefeed advance, the clutch gear 223 moves towards the drive roller 203 to engage the wave generator 217 (elliptical disc). Wrapped freely around the circumference of the wave generator 217 is the flex spline 219, a flexible band with gear teeth (not shown) on the outside surface, which engage the teeth (not shown) on the interior surface of the rigid circular spline 221. The gear teeth of the flex spline 219 engage the gear teeth of the circular spline 221 at two points, which coincide with the two opposite intersections of the major axis of the ellipse and the pitch diameter of the gear engagement. It is important to note that the number of gear teeth on the flex spline 219 is less than the number of teeth on the circular spline 221, and the flex spline 219 is restrained from axial rotation. Therefore, each rotation of the wave generator 217 translates to a rotation of the circular spline 221 in the same direction. The angle of this rotation is dictated by the difference in the number of teeth between the circular spline, and the flexspline. Overall, with the clutch gear 223 keyed to the motor shaft 207, the motion from the motor 201 is transmitted directly to the wave generator 217, whose rotational movement

transmits the driving force to the circular spline 221 through the large gear ratio reduction between the flex spline 219 and the circular spline 221. As the circular spline 221 is rigidly connected to the drive roller shaft 205, the motion from the motor 201 to the drive roller 203 is complete.

Therefore, the position of the keyed clutch gear 223 along the motor shaft 207 will operate the required drive mode accordingly.

The positioning of the keyed clutch gear 223 may be obtained through various means, including solenoid control, or carriage motion activation. Determining the position the clutch gear takes is set by the printer control system (not shown) which recognizes the image data content to decide whether high speed or high precision linefeed advances are required. For example, page load, page eject, or blank space advance sequences requires a high speed advance, while photo printing may require a high precision advance.

With the harmonic drive 215, high positional/rotational precision is assured because it has many simultaneous-mating teeth built-in and because these teeth mate with one another in two symmetrical positions at 180 degrees. This means influences of tooth pitch errors and accumulated pitch errors on rotational accuracy are equalized to assure high positional/rotational precision. Furthermore, through the harmonic drive 215, the drive mechanism 100 achieves the desired highly precise paper advance without extra requirements on the encoder disc 207. The harmonic drive 215 has very little gear backlash. Therefore, detection of the drive roller rotational positions can be done through detecting the rotational positions of the motor 201 instead by the encoder disc 109 mounted to the motor 201. Since the drive roller 203 rotates much slower than the motor 201 when the drive mechanism operates in the second mode, the encode disc 209 can have a relatively small size as compared to the conventional drive mechanism.

Because the harmonic drive 215 has only three basic components despite effective speed reduction ratios, and since all three components are co-axially aligned, the harmonic drive 215 can be easily built into component-assembled products allowing for simple configurations. Transmissions in printer mechanisms can be made smaller in size and lighter in weight because the harmonic drive provides the same levels of torque and speed reduction ratios as conventional gearing mechanisms despite the fact that it is 1/3 the size of conventional products in terms of capacity and at least 1/2 the weight.

Different from the typical driving force transmission apparatus such as gear train, every tooth in the harmonic drive is subjected to very little force but provides a high capacity of torque. Because the number of simultaneously mating teeth in the flexspline accounts for some 30% of the total number of teeth, and these teeth come into contact with one another face to face, every tooth is subjected to a minimum of force while providing a maximum of torque. The mating portion of each tooth is subjected to very little slide motion. Therefore, motion loss due to friction is reduced substantially. This is why the harmonic drive can maintain a high level of efficiency, allowing for the down sizing of driving motors as a result.

With the harmonic drive, quiet and vibration-free operations are possible because the teeth do not come into rolling contact with one another, and since the circumferential speed of each tooth is low, the teeth provide a well-balanced force.

What is claimed is:

1. A printer drive mechanism, comprising:

a drive motor;

a drive roller for feeding a media sheet towards and through an image printing area;

a drive transmission connecting the drive roller to the motor for turning the drive roller at a variety of speeds; and

a speed selector disposed in the transmission for selectively turning the drive roller at a fast speed to move said media sheets quickly to said printing area, and for selectively turning the drive roller at a slow speed to move said media sheets with precision for image printing while in said printing area.

2. The drive mechanism of Claim 1, wherein the speed selector includes a clutch coupled to the motor, and movable between a first and a second position for said fast and slow speeds.

3. The drive mechanism of claim 1, wherein the drive transmission includes a low-reduction and a high-reduction mechanism, and wherein the speed selector selectively engages the drive roller with the drive motor through one of the low-reduction and high-reduction transmission mechanisms such that the drive roller feeds the media sheet at the fast or the low speed respectively.

4. The drive mechanism of Claim 3, wherein the high-reduction transmission mechanism is designed to be a harmonic drive for providing a highly precise line feed characteristic to the drive roller.

5. The drive mechanism of Claim 4, further comprising an encoder disk coupled to the motor for detecting rotational positions of the drive roller through rotational positions of the motor.

6. A printer drive mechanism, comprising:

a drive motor;

a drive roller for feeding a media sheet towards and through an image printing area;

a low-reduction gear train connected to the drive roller and selectively engagable with the motor for selectively connecting the drive roller to the motor and for turning the drive roller at a first speed;

a harmonic drive connected to the drive roller and selectively engagable with the motor for selectively connecting the drive roller to the motor and for turning the drive roller at a reduced speed; and

a clutch movable between a first and a second position for selectively engage one of the low-reduction gear train and the harmonic drive with the motor.

7. A process for feeding a media sheet in a printer, comprising:

feeding the media sheet at a first speed towards a print zone in the printer before the media sheet has reached the print zone; and

feeding the media sheet at a reduced second speed through the print zone where images are printed onto the media sheet.

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**DUAL-SPEED DRIVE MECHANISM**

ABSTRACT OF THE DISCLOSURE

A drive mechanism embodiment of the present invention for feeding a media sheet in a printer includes a drive motor, a drive roller for feeding media sheets toward and through a printing area, and a transmission system for connecting the drive roller to the motor to provide two-speed power to the drive roller. Furthermore, a speed selector is disposed in the transmission system for selectively turning the drive roller at a fast speed to move said media sheets quickly to and out of said printing area, and for selectively turning the drive roller at a slow speed to move said media sheets with precision for image printing while in said printing area.

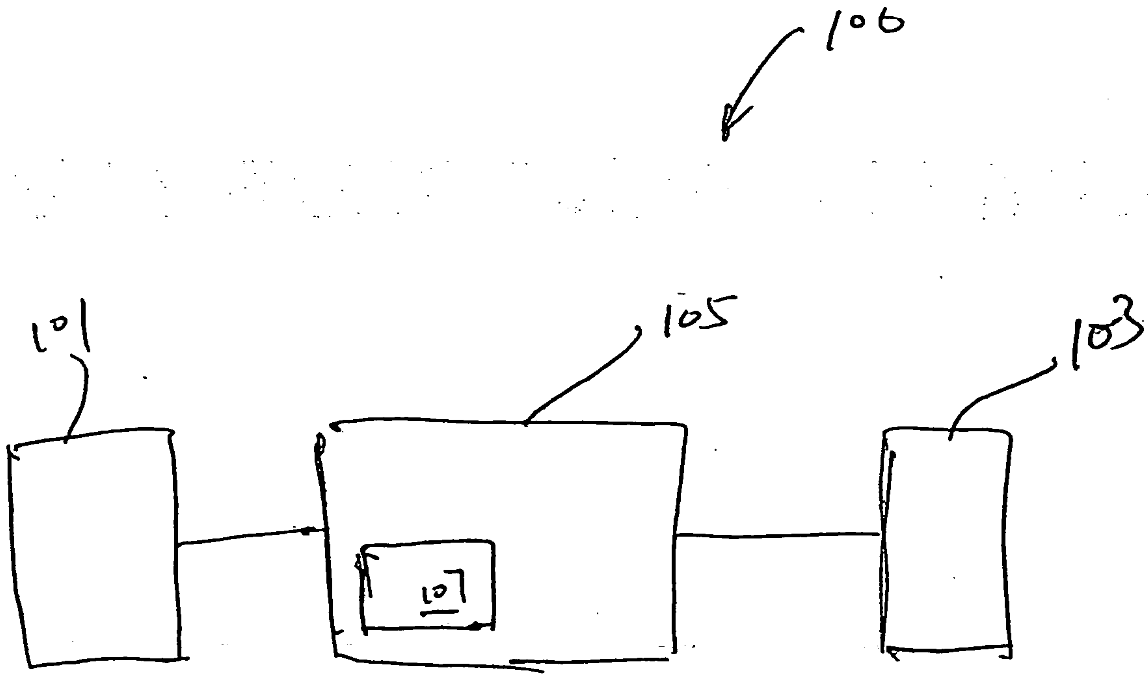
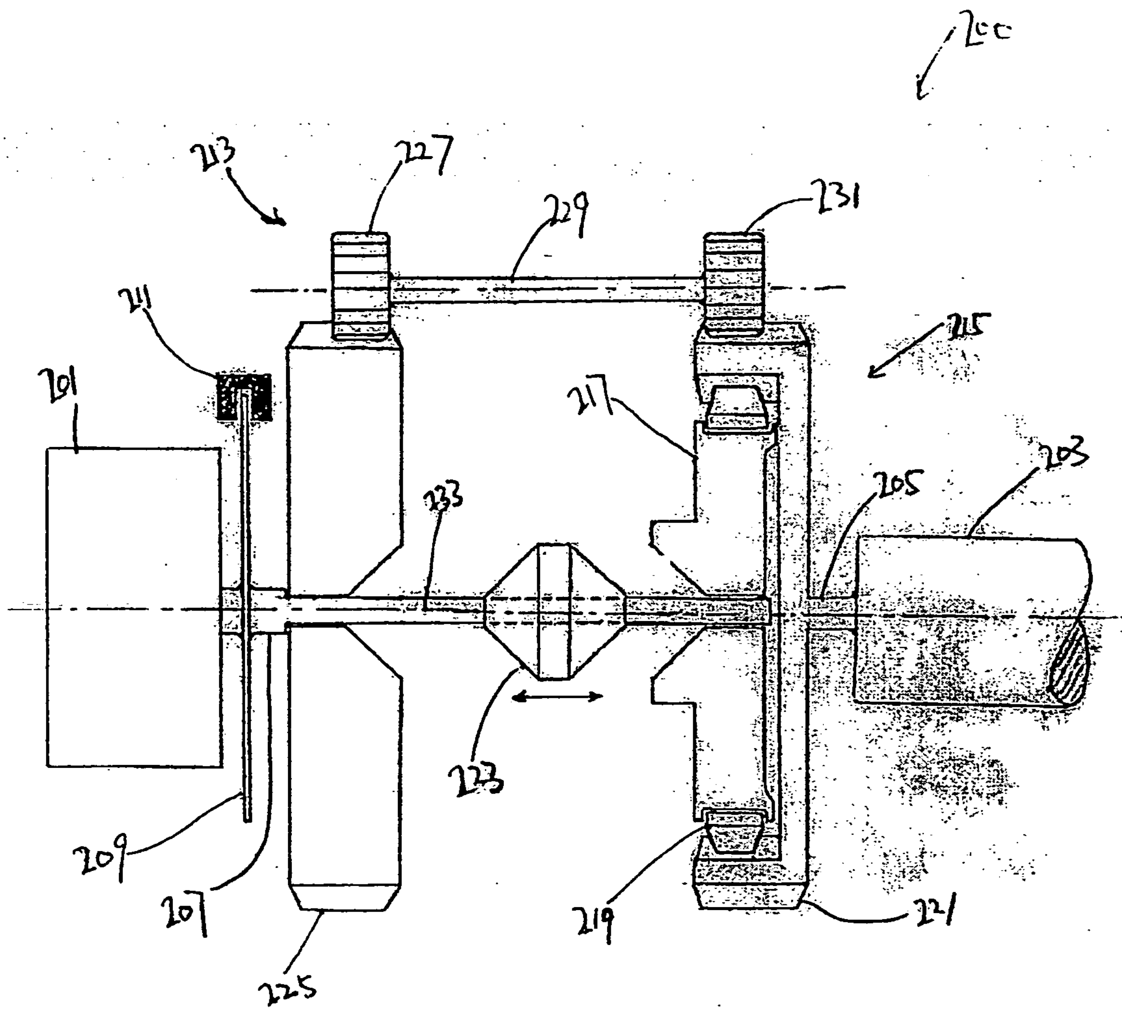



Fig. 1.


200
213
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221

Fig 2

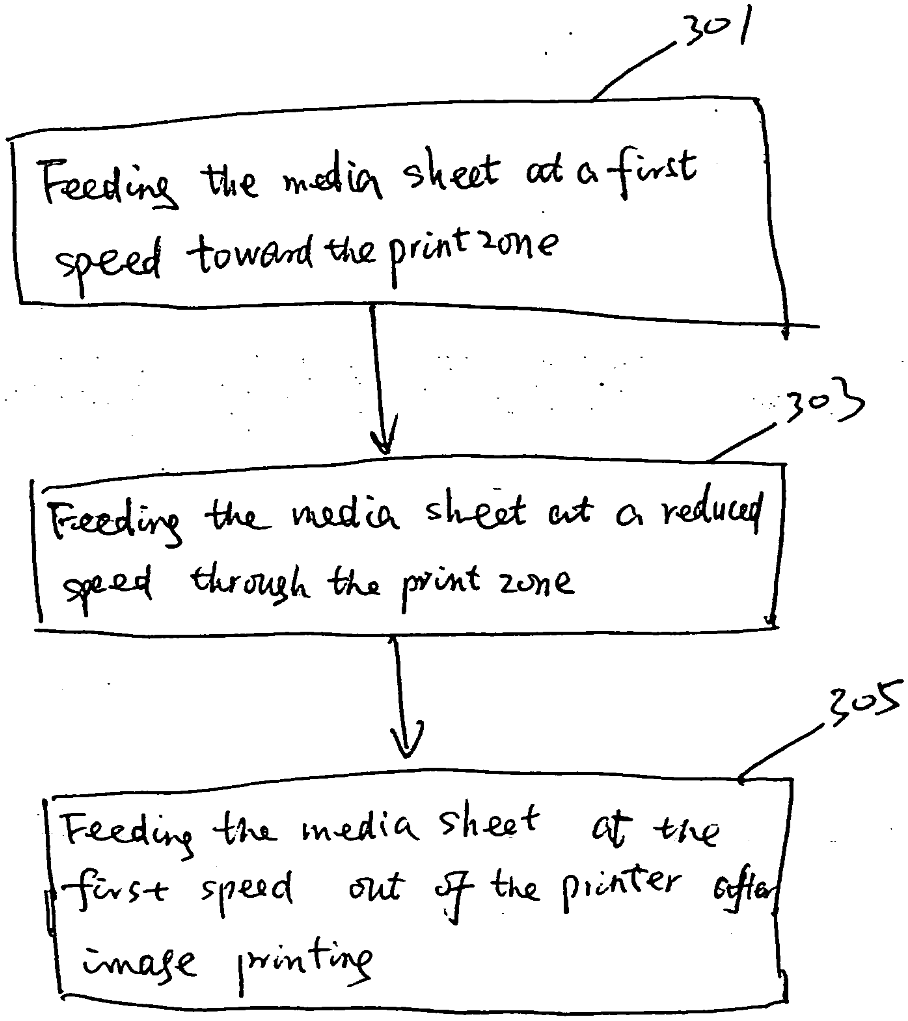
301
Feeding the media sheet at a first speed toward the print zone
303
Feeding the media sheet at a reduced speed through the print zone
305
Feeding the media sheet at the first speed out of the printer after image printing

Fig. 3